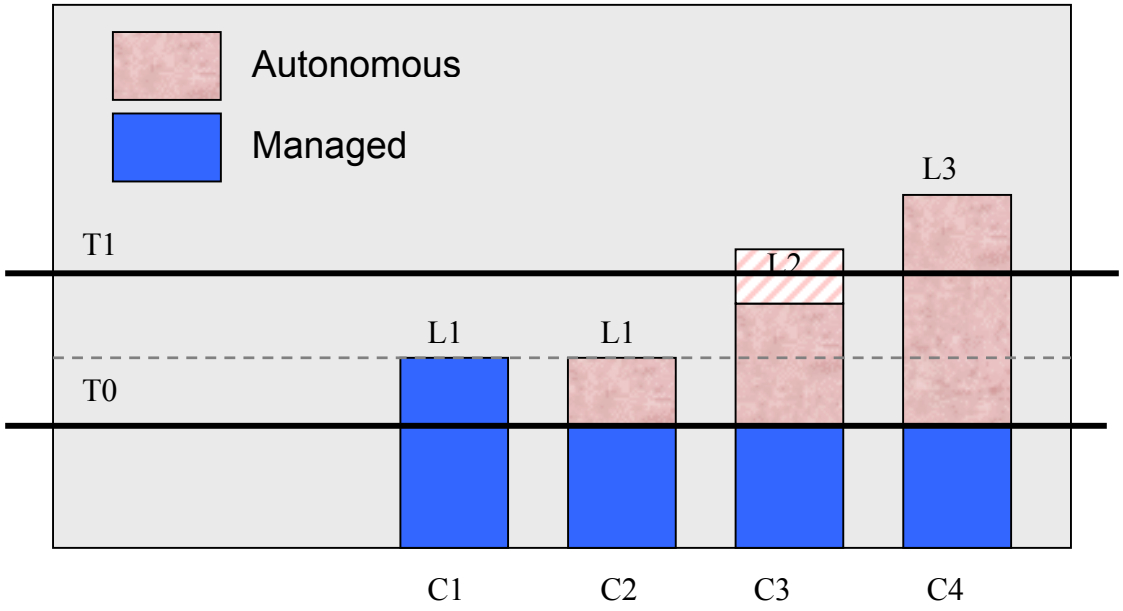
1.1 Experimental Design

- Objectives:
  - Mixed Operations in very high traffic density sectors are safe and don't degrade traffic throughput and efficiency compared to operations with all managed aircraft
  - The number of total aircraft in a sector can safely be increased far beyond ATSP manageable levels if the number of managed aircraft is at or below current day high density
  - Mixed operations can safely recover from typical flow disrupting events and be re-organized according to the revised flow constraints at least as well as in all managed operations.

- Shakedown in January:
  - Calibrate Threshold T0 to be an appropriate amount of managed aircraft in mixed operations
  - Calibrate T1 to be clearly above maximum traffic when managed
  - Validate L1, L2, L3 to be reasonable levels
- Run Mixed Operations and all managed at L1
- Agree on qualitative performance measures

1.1.1 Independent Variable

The independent variable in the present study will vary along four levels, testing two different hypotheses. The conditions will be designated as follow:



L1: High DAG Managed
L2: Intermediate DAG CE5
L3: High DAG CE5
T0: Threshold approximating current day monitor alert parameter
T1: Threshold above which managed only operations will definitely fail.

The C1-C2 comparison examines the feasibility of mixed airspace. It compares workload, safety, and efficiency metrics between autonomous-managed mixed and 100% managed airspace.

The C2-C3-C4 comparison shows the effects of scaled autonomous traffic on controller's workload. The number of managed aircraft is fixed between the three conditions and only the number of autonomous aircraft is increased to scale the traffic.

We have not determined how to address recovery from flow disrupting events in our simulation. Two best options seem to be 1) to embed local flow disrupting events within all scenarios (e.g. re-assigning RTAs for few selected aircraft) or 2) to demonstrate this capability outside the test matrix.

1.1.2 Experiment Schedule

According to the proposed experimental plan, three runs will be held on a daily basis (see Appendix A and B. Appendix B is a proposed 90-min per run schedule based on August experiment design meeting). Each day, participants will complete a run in one of the four variations of a single scenario (A - D) for each of the four operational conditions (1 – 4). At the end of the study, participants will have completed four runs in each condition and each scenario. The presentation order of the four modes of operation and the three scenarios will be counterbalanced in order to reduce the likelihood of a learning bias (see Table 1).

Table 1. Presentation of Conditions and Scenarios for Data Collection Runs.

Day 3		Day 4		Day 5		Day 6		Day 7		Day 8	
Cond	Scen	Cond	Scen	Cond	Scen	Cond	Scen	Cond	Scen	Cond	Scen
1	A	4	C	3	D	2	B	3	A	4	D
3	B	2	A	1	C	4	A	1	B		
2	D	1	D	4	B	3	C	2	C		

Condition 1 = 100% managed airspace at L1 traffic level
Condition 2 = mixed airspace at L1 traffic level
Condition 3 = mixed airspace at L2 traffic level
Condition 4 = mixed airspace at L3 traffic level

If the pilot and controller training can be completed in two days as planned, then we will have two extra data collection runs to be used as make-up or to demonstrate other

capabilities (e.g. weather?). We should also consider using January "dress rehearsal" as an opportunity to demonstrate capabilities not in the experiment design.

1.1.3 Scenario Logistics

We have agreed to separate the Ames and Langley fleets for CE-5 conditions. Following are some of the constraints and assumptions that factored into the design:

- Ames fleet consists of 8 single piloted planes. Langley fleet consists of 12 single piloted planes.
- Each pilot flies twice through the scenario. There is a 5 minute (?) gap between the two runs to allow pilots to fill out a short questionnaire and for the researchers to set up the simulation.
- CE-11 problem is run at the beginning of each scenario. Ames and Langley aircraft can run CE-11 problem simultaneously in the same airspace.
- Ames and Langley aircraft cannot be present "simultaneously" in the same en route sector (i.e. Bowie, Falls, Ardmore, and Amarillo).
    - Overflights could be spatially segregated by assigning them to different sectors (i.e. Amarillo and Ardmore).
    - Arrival fleets need to be staggered by 2 minutes so that the fleets nominally don't interact at the meter fix, although the overall system can handle the interactions if they occur.
- The configuration of the fleets needs to be consistent across all conditions (1-4) to allow valid comparisons across conditions.
- Because CE-11, CE-5 arrivals, and CE-5 overflights are three distinct types of problems, they should be analyzed independently. In addition, it would be ideal if the planes in each sector are analyzed separately since each sector has unique characteristics.

Based on these assumptions, joint simulation scenario design is proposed (see Joint Sim Scenario Organization document).

Appendix A: Proposed schedule – 75 min runs

Time (EST)	Langley	Ames	Time (PST)
8:00 AM			5:00 AM
8:30 AM			5:30 AM
9:00 AM	Debrief / Briefing		6:00 AM
9:30 AM			6:30 AM
10:00 AM	Practice Runs	Short Briefing	7:00 AM
10:30 AM	Data Collection	Data Collection	7:30 AM
11:00 AM	(includes 15 min	(includes 15 min	8:00 AM
11:30 AM	check-in)	check-in)	8:30 AM
12:00 PM	Lunch	Break	9:00 AM
12:30 PM			9:30 AM
1:00 PM	Data Collection	Data Collection	10:00 AM
1:30 PM	(includes 15 min	(includes 15 min	10:30 AM
2:00 PM	check-in)	check-in)	11:00 AM
2:30 PM	Break	Lunch	11:30 AM
3:00 PM			12:00 PM
3:30 PM	Data Collection	Data Collection	12:30 PM
4:00 PM	(includes 15 min	(includes 15 min	1:00 PM
4:30 PM	check-in)	check-in)	1:30 PM
5:00 PM	Short Debrief	Debrief / Briefing	2:00 PM
5:30 PM			2:30 PM
6:00 PM			3:00 PM
6:30 PM			3:30 PM
7:00 PM			4:00 PM
7:30 PM			4:30 PM
8:00 PM			5:00 PM
8:30 PM			5:30 PM
9:00 PM			6:00 PM

Appendix B: Proposed schedule – 90 min runs

Time (EST)	Langley	Ames	Time (PST)
9:00 AM	Debrief / Briefing		6:00 AM
10:00 AM	Practice Runs	Short Briefing	7:00 AM
10:15 AM	Data Collection	Data Collection	7:15 AM
10:30 AM	(includes 15 min	(includes 15 min	7:30 AM
10:45 AM	check-in)	check-in)	7:45 AM
11:00 AM			8:00 AM
11:15 AM			8:15 AM
11:30 AM			8:30 AM
11:45 AM			8:45 AM
12:00 PM	Lunch	Break + Discussion	9:00 AM
1:00 PM	Data Collection	Data Collection	10:00 AM
1:15 PM	(includes 15 min	(includes 15 min	10:15 AM
1:30 PM	check-in)	check-in)	10:30 AM
1:45 PM			10:45 AM
2:00 PM			11:00 AM
2:15 PM			11:15 AM
2:30 PM			11:30 AM
2:45 PM	Break + Discussion	Lunch	11:45 AM
3:45 PM	Data Collection	Data Collection	12:45 PM
4:00 PM	(includes 15 min	(includes 15 min	1:00 PM
4:15 PM	check-in)	check-in)	1:15 PM
4:30 PM			1:30 PM
4:45 PM			1:45 PM
5:00 PM			2:00 PM
5:15 PM			2:15 PM
5:30 PM	Debrief / Briefing	Debrief / Briefing	2:30 PM
5:45 PM			2:45 PM
6:00 PM			3:00 PM
6:30 PM			3:30 PM